OCCURRENCE OF TWO SPECIES OF ELASMOBRANCHS, *CARCHARHINUS LEUCAS* AND *PRISTIS MICRODON*, IN BETSIBOKA RIVER, WEST MADAGASCAR

by

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RÉSUMÉ. - Présence de deux espèces d'Élasmobranches, *Carcharhinus leucas* et *Pristis microdon*, dans la rivière Betsiboka, ouest de Madagascar.

En septembre 2001, une mission a été effectuée dans l'ouest de Madagascar pour étudier les Élasmobranches d'eau douce. Sept spécimens d'Élasmobranches ont été récoltés dans le bassin de la rivière Betsiboka, près de Marovoay, ouest de Madagascar : 1 mâle et 2 femelles de requin-bouledogue, *Carcharhinus leucas*, et 1 mâle et 3 femelles du poisson-scie à large dents, *Pristis microdon*. Les analyses ont montré que l'eau des sites présumés de capture de *P. microdon* était douce, mais qu'elle était de qualité incertaine pour les sites de captures de *C. leucas*. L'analyse de la composition du sérum sanguin suggère que les spécimens de *P. microdon* ont été capturés en eau douce et ceux de *C. leucas* en eau saumâtre.

Key words. - Elasmobranchii - *Carharhinus leucas* - *Pristis microdon* - Madagascar - Freshwater.

Although they are principally marine, elasmobranchs have been known to occur in freshwater. There are many definitions of freshwater as stated by Schwartz (1995) and freshwater elasmobranchs have been defined by Zorzi (1995) as those « sharks and rays that frequent rivers and lakes ». Compagno and Cook (1995) pointed out that 10 genera, four families and approximately 43 species of sharks and rays penetrate freshwater environments well beyond the tidal reaches of river mouths. Compagno (2002) reviewed freshwater and estuarine elasmobranchs in the Indo-Pacific regions and did not mention occurrences of elasmobranchs in rivers and lakes of Madagascar. He reported occurrences of freshwater elasmobranchs in the adjacent area of Madagascar such as South Africa and Mozambique (Compagno *et al*., 1989).

A Japanese Research Team has made extensive field surveys in various regions of the world to elucidate taxonomical, ecological, physiological and biochemical aspects of freshwater elasmobranchs (Taniuchi, 2002). These field surveys of freshwater elasmobranchs, distributed in southeast Africa, were made because of the lack of recent information. Collections were made in South Africa, Mozambique and Madagascar during August and September, 2000. Useful information were obtained from fishermen at sites in several river basins of west Madagascar. The basins of the Betsiboka and Mahajamba Rivers were investigated for freshwater and brackish elasmobranchs in September 2001. Several specimens of two species of elasmobranchs, *Carcharhinus leucas* (Müller & Henle, 1841) and *Pristis microdon* Latham, 1794, were collected.

These specimens do not represent first records for the freshwater of Madagascar since Kiener (1963) has already reported on their occurrence in some Malagasy streams, but the recent survey provided original information on biometrical features, blood serum composition, and physical characteristics of their environment in Madagascar, herein presented.

MATERIALS AND METHODS

A field survey in two river basins near Marovoay, west Madagascar, was carried out during three weeks in September

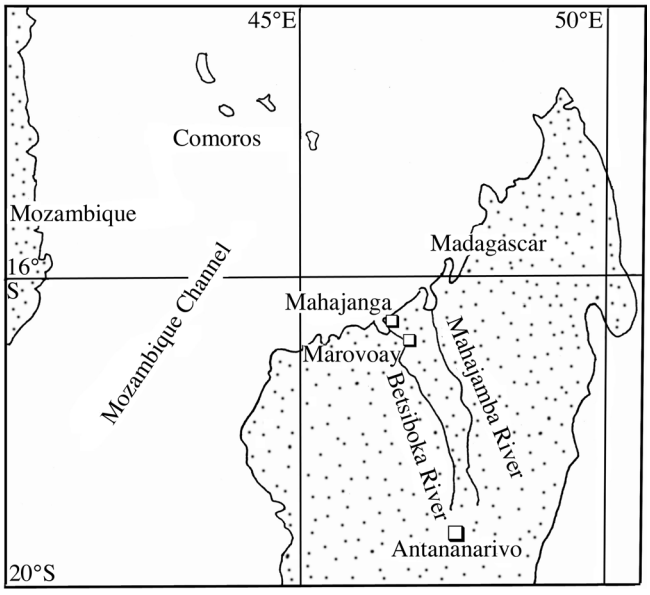

Figure 1. - Map of west Madagascar showing sampling localities for the two species of elasmobranchs, *Carcharhinus leucas* and *Pristis microdon*, near Marovoay along the Betsiboka River.

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2001. Marovoay (16°6'S-46°38'E) is located approximately 50 km upstream from the river mouth (Fig. 1). Four pristids were captured with shrimp gillnets and three carcharhinids, by longlines, from Boanamary located at the river mouth of Betsiboka River. We did not obtain detailed information on the catch sites of the specimens, since local fishermen provided sawfishes through a fish dealer in Marovoay and a fisherman brought bull sharks directly to us, asserting that they were caught in the Betsiboka River. Notwithstanding this deficiency of the exact localities, at least sawfishes were captured in the vicinity of our sampling sites, Marovoay. Measurements follow those of Garrick (1982) for carcharhinids and Bigelow and Schroeder (1953) for pristids. The total length (TL) was measured from snout to tip of upper caudal fin with tail in natural position. The 997 mm TL male *C. leucas* was deposited in the collections of the Marine Science Museum, Tokai University (MSM 02-1) and the 789 mm TL male *P. microdon* in the Museum of Tokyo University of Fisheries (MTUF 30202), Tokyo, Japan.

Geographical coordinates (longitude and latitude) for the Malagasy localities were obtained through the Alexandria Digital Library Gazetter Server.

Blood samples of 10-20 ml were obtained from the caudal vein of each fish using a disposable syringe 18G needle. The serum was separated by centrifugation in the field. Concentrations of sodium, potassium, calcium and magnesium were analyzed in the laboratory by ion-analyser (AVL, Co Ltd.), chlorine with a chroridmeter (Bucher, Co. Ltd), osmolality using an osmometer (Wescor, 5500 Vapper Pressure) and urea content following the urease-indophenol method. Ambient waters were sampled from the Betsiboka River basin. Water analysis was conducted using a Horiba, U-10 type, which measures salinity, conductivity, turbidity, dissolved oxygen (DO) and pH.

RESULTS

The three carcharhinids specimens agreed with the features of the bull shark, *Carcharhinus leucas*, as described by Garrick (1982), Compagno (1984), Taniuchi *et al*. (1991) and Taniuchi *et al*. (1991). Locality, sex, and length for each specimen are given in table I, and morphometric and meristic data in table II, indicating they were normal specimens. These bull sharks were immature as they have undeveloped reproductive organs. Local fishermen reported us that *C. leucas* was regularly observed in the rivers and estuaries in west Madagascar.

The four pristids were characterized by having stout body with acute angle of the pectoral fins; broad, flattened snout with 19-21 rostral teeth on each side; first dorsal fin origin well in front of pelvic fin insertion, and well-defined lower lobe of caudal fin. Based upon these characteristics, the four pristids were identified as *Pristis microdon*, according to Compagno *et al*. (1989), Taniuchi *et al*. (1991) and Taniuchi *et al*. (1991). Locality, sex, and length for each specimen is tabulated in table I, and morphometric and meristic data in table II. Three of these four specimens were small, less than 800 mm in total length. An umbilical scar on the abdomen was still visible, suggesting that they were neonates. The larger 1,450 mm TL specimen was immature as shown by its short and soft claspers. All pristids were captured with shrimp gillnets in the main stream of Betsiboka River where water quality was nearly freshwater (Tab. III). Local fishermen and dealers said that pristids were common in several rivers of west Madagascar. Usually, pristids are not targeted for commercial fisheries, but when accidentally captured, they are discarded or consumed by local people.

Ionic concentrations, urea content and osmolality for each species are compared to those reported elsewhere (Tabs IV, V). The condition of the specimens was not good, hence only ionic concentration of chlorine, sodium, and calcium were analysed. No large differences in ion concentrations of chlorine, calcium, and urea were found between the two species, but sodium concentration differed between the two species. Osmolality was very high ranging from 923 to 956 mosm/kg in *C. leucas* and 685 to 782 mosm/kg in *P. microdon*.

DISCUSSION

Compagno (2002) stated that many freshwater elasmobranchs in the tropical riverine habitats worldwide might be nearing extinction. Based on over hundred specimens collected during extensive surveys of freshwater elasmobranchs in Southeast Asia, South America, west Africa, Oceania, Middle America, Indo-subcontinent, and Indochina Peninsula, much information was obtained on their taxonomic, ecological, physiological, and biochemical aspects (Taniuchi, 2002).

Field surveys were conducted in 2001 in southeast Africa, included Mozambique and Madagascar allowed to collect specimens of *C. leucas* and *P. microdon* in the freshwater of west Madagascar. Kiener (1963) reported on the occurrence of these species in the Lake Kinkony (16°8'S-45°50'E) near the Betsiboka River. He stated that the bull shark was not rare in Malagasy rivers, where up to 100 km upstream from the estuaries it is known as "ankiho beloa", which means bull shark. Individuals are generally small with a length ranging from 1 to 1.5 m. According to inhabitants surrounding lake Kinkony, some individuals never go downstream to the sea. Kiener (1963) stated that several specimens of *Pristis microdon* were caught upstream in some rivers of western Madagascar where it was kown as "vahavaha", its flesh was eaten and the saws were displayed as trophees in front of fisherman huts. A drawing of a 3 m specimen labelled *P. microdon* (plate 44 in Kiener, 1963) is not accurate but the rostrum has 18 rostral teeth. No specimen, nor rostrum were found in the MNHN collection where Kiener could have deposited samples from Madagascar. The fist record of a sawfish in Malagasy freshwater is that of Poisson (1938) in a French weekly magazine published in Madagascar in February 1938. A specimen of about 3 m long (length estimated from the photo included in the article) was caught in July 1936 in the river Mangoky, at Beroroha (South-West of Madagascar, 21°40'S-45°10'E), i.e. 200 km from the estuary and 199 m above the sea level.

Fourmanoir (1961) reported on the occurrence of *C. leucas* on the west coast of Madagascar: he listed 11 specimens from 146 to 280 cm TL found in the « eaux intérieures » of Nosy-Iranza, Nosy-Kisimany and Nosy Bé (13°20'S-48°15'E), that means most probably in the shallow marine waters of these small islands than in "continental waters". The same author (Fourmanoir, 1963) reported on the capture of two specimens of sawfish (333 and 350 cm TL), identified as *Pristis perotteti* but fitting with *P. microdon*, from shallow bays of the Befotaka and Ambato (west Madagascar).

The bull shark is the most common species of freshwater elasmobranchs worldwide. Bass *et al*. (1973, 1986), Compagno *et al*. (1989) reported on its occurrence in southeast Africa from Cape St Francis to Mozambique, pointing out that youngs often penetrate into rivers. Furthermore, a fatal mass poisoning involving 188 patients in November 1993 in Manakara (SE of Madagascar, 22°74'S-48°1'E) was attributed to the ingestion of the meat of a

Species name	Locality	Date (2001)	Sex	TL (mm)	Catalogue n°
Carcharhinus leucas	River mouth	19 September	Female	1045	-
Carcharhinus leucas	River mouth	19 September	Female	1121	-
Carcharhinus leucas	River mouth	19 September	Male	997	MSM 02-1
Pristis microdon	Near Marovoay	2 September	Male	793	-
Pristis microdon	Near Marovoay	4 September	Female	792	-
Pristis microdon	Near Marovoay	7 September	Male	789	MTUF 30202
Pristis microdon	Near Marovoay	10 September	Male	1450	-

Table I. - Locality, sampling date, length and sex of the two species of elasmobranchs, *Carcharhinus leucas* and *Pristis microdon*, captured in the Betsiboka River basin, west Madagascar.

Table II. - Morphometric and meristic data of the specimens of *Pristis microdon* and *Carcharhinus leucas* captured in the Betsiboka River basin, west Madagascar.

Species	*Pristis microdon*								*Carcharhinus leucas*					
TL (mm)	789		792		793		1450		997		1045		1121	
Sex	male		female		male		male		male		female		female	
	mm	%TL	mm	%TL	mm	%TL	mm	%TL	mm	%TL	mm	%TL	mm	%TL
Snout length from eye	236	29.9	226	28.3	223	28.1	312	21.5						
Snout tip to outer nostrils	226	28.6	219	27.7	214	26.9	352	24.3	22	2.2	27	2.6	32	2.9
Snout tip to mouth	267	33.8	259	32.7	255	32.2	409	28.2	56	5.6	64	6.1	70	6.2
Snout tip to eye	234	29.7	226	28.5	225	28.3	368	25.3	50	5	57	5.4	69	6.2
Snout tip to spiracle	262	33.2	254	32			406	28						
Snout tip to 1st gill opening	332	42.1	225	28.4	322	40.6	532	36.7	169	17	170	16.3	202	18
Snout tip to 5th gill opening	359	45.5	350	44.2	347	43.8	584	40.2	220	22.1	234	22.4	246	21.9
Snout tip to pectoral insertion	321	40.1	307	38.8	295	37.2	512	35.3	206	20.7	224	21.4	230	20.5
Snout tip to pelvic insertion	489	61.2	470	59.3	482	60.8	635	43.8	522	52.4	552	52.8	588	52.5
Snout tip to 1st dorsal origin	444	56.3	437	55.2	432	54.5	735	50.7	301	30.2	309	29.6	314	28
Snout tip to 2nd dorsal origin	576	73	578	73	571	72	980	67.6	636	63.8	666	63.7	708	63
Snout tip to anal origin									649	65.1	696	66.6	715	63.8
Snout tip to upper caudal origin	668	84.7	668	84.3	668	84.2	1154	79.5	751	75.3	798	76.4	837	74.7
Internarial width	19	2.4	18	2.3	18	2.3	29	2	66	6.6	68	6.3	69	6.2
Mouth width	46	5.8	45	5.7	45	5.7	76	5.2	110	11	110	10.5	107	9.5
Intersapce between 1st gill slits	81	10.2	75	9.5	75	9.5	150	10.3						
Interspace between 5th gill slits	54	6.8	52	6.6	53	6.7	105	7.2						
1st gill slit length	12	1.5	11	1.4	8	1	21	1.4	38	3.8	37	3.5	35	3.1
3rd gill slit length	13	1.7	13	1.6	7	0.9	23	1.6	50	5	48	4.6	47	4.2
5th gill slit length	12	1.5	9	1.1	6	0.7	18	1.2	33	3.3	33	3.2	38	3.4
Eye diameter	16	2	17	2.1	14	1.8	22	1.5	14	1.4	15	1.4	14	1.2
Interorbital width	36	4.6	44	5.6	42	5.2	85	5.9						
Interspiracular width	39	4.9	37	4.7	37	4.7	63	4.3						
Spiracular length	14	1.7	13	1.6	12	1.5	22	1.5						
First dorsal fin overall length	82	10.4	87	11	79	10	172	11.8	148	14.8	165	15.8	170	15.2
First dorsal fin base length	59	7.5	64	8.1	58	7.3	118	8.1	117	11.7	130	12.4	137	12.2
First dorsal fin height	61	7.7	59	7.4	62	7.8	112	7.7	92	9.2	118	11.3	112	10
Second dorsal fin overall length	67	8.5	68	8.6	68	8.6	143	9.9	73	7.3	90	8.6	95	8.5
Second dorsal fin base length	43	5.4	46	5.8	41	5.2	94	6.5	55	5.5	54	5.2	63	5.6
Second dorsal fin height	61	7.7	62	7.8	58	7.3	112	7.7	35	3.5	40	3.8	41	3.7
Pectotal base length	97	12.3	83	10.5	109	13.7	198	13.6	66	6.6	84	8	88	7.9
Pectoral anterior margin length	97	12.3	83	10.5	109	13.7	190	13.1	189	19	199	19	210	18.7
Pectoral distal margin length	103	13.1	107	13.5	104	13.1	213	14.7	170	17.1	176	16.8	190	16.9
Pectoral posterior margin length	36	4.6	47	5.9	44	5.5	70	4.8	54	5.4	60	5.7	65	5.8
Anal fin overall length									79	7.9	78	7.5	88	7.9
Anal fin base length									48	4.8	57	5.5	61	5.4
Anal fin height									42	4.2	46	4.4	47	4.2
Pelvic fin overall length	71	9	68	8.6	71	9	142	9.8	92	9.2	95	9.1	101	9
Pelvic fin base length	45	5.7	46	5.8	35	4.4	78	5.4	58	5.8	74	7.1	75	6.7
Pelvic fin anterior margin length	53	6.7	51	6.4	52	6.6	106	7.3	58	5.8	77	7.4	78	7
Pelvic fin posterior margin length	49	6.2	49	6.2	49	6.2	117	8.1	72	7.2	75	7.2	82	7.3
Caudal fin dorsal lobe length	126	16	127	16	129	16.2	239	16.5	261	26.2	296	28.3	295	26.3
Caudal fin ventral lobe length	66	8.3	68	8.6	69	8.7	127	8.8	119	11.9	121	11.6	132	11.8
Caudal fin notch depth									27	2.7	27	2.6	26	2.3
Clasper length from origin	31	3.9			28	3.5	52	3.6	47	4.7				
Number of rostral teeth left- right	20 -21		19 - 18		21 - 21		20 -20							
Number of teeth in upper jaw									13+1+13		12+2+12			
Number of teeth in lower jaw									12+1+13		12+1+12			

Table III. - Water quality of sampling localities in the Betsiboka River for *Carcharhinus leucas* and *Pristis microdon*.

	River mouth		Main river near Marovoay						
Date (2001)	11 September		31 August				31 August		
Time	10.55		9.10				13.21		
Depth	Surface	Bottom (4 m)	Surface	2.5 m	4.5 m	Bottom (9 m)	Surface	3 m	Bottom (6.5m)
pH	9.33	8.34	7.66	8.07	7.62	7.84	7.79	7.71	7.70
Conductivity (μS/cm)	45.10	7.42	0.66	0.66	0.66	0.66	1.21	1.33	1.33
Turbidity (NTU)	6.00	5.00	171.00	175.00	190.00	245	41.00	59.00	110.00
DO (mg/l)	7.30	6.70	7.79	7.15	7.30	7.99	8.16	8.08	7.92
Temperature (°C)	26.60	26.40	23.60	23.60	23.60	23.60	24.20	23.8	23.80
Salinity (‰)	2.94	2.97	0.02	0.02	0.02	0.02	0.05	0.06	0.06

Table IV. - Ion and urea concentration and osmolality of blood serum of *Carcharhinus leucas* from various regions.

Sample location	Data	Ion concentration (mmol/l)					Urea	Osmolality
		Cl	Na	Ca	Mg	K	(mmol/l)	(mOsm/kg)
West Madagascar	Present study	Range 70-117	Range 138-191	Range 0.5-2.9			Range 170-228	Range 923-956
S.F.del Fiel Lagoon	Sosa-Nishizaki *et al*., 1998	236	244	5.6	2.2	12.1	84	703
Usumacinta River	Sosa-Nishizaki *et al*., 1998	210	236	6.4	2.2	14.4	98	705
Gulf of Mexico	Thorson *et al*., 1973	288	288	5.7	3.8	6.1	356	
Lake Nicaragua	Thorson *et al*., 1973	219	245	4.5	1.4	6.4	169	
Colorado River	Thorson *et al*., 1973	207	288	4.5	2.1	6.3	138	
Adeleide River	Otake, 1991	Mean + SD 225 ± 10	Mean + SD 237 ± 10	Mean + SD 3.9 ± 0.1	Mean + SD 1.5 ± 0.01	Mean + SD 8.6 ± 1.1	Mean + SD 104 ± 4.7	Mean + SD 673

Table V. - Ion and urea concentration and osmolality of blood serum of *Pristis microdon* from various regions.

Sample location	Data	Ion concentration (mmol/l)					Urea	Osmolality
			Cl	Na	Ca	Mg	K	(mmol/l)	(mOsm/kg)
West Madagascar	Present study	Range	121-210	214-264	1.6-3.7			182-214	685-782
Indragiri River	Hirano, 1977	Mean	168	156	2,8	1,2	12,3	87	532
Gilbert River	Otake, 1991	Mean + SD	188 ± 35	212 ± 28	3.7 ± 0.3	1.4 ± 0.2	7.1 ± 2.1	88.8 ± 9.2	594 ± 82
Daly River	Otake, 1991	Mean + SD	195 ± 8	204 ± 8	2.3 ± 0.4	1.3 ± 0.1	9.7 ± 2.1	78.4 ± 10.7	535 ± 41
Lake Murray	Otake, 1991	Mean + SD	174 ± 10	186 ± 8	3.6 ± 0.2	1.2 ± 0.1	7.9 ± 1.2	66.9 ± 6.6	509 ± 30

bull shark (Boisier *et al*., 1994, 1995). This was a unique case of ichthyosarcotoxism by shark meat causing the death of 30% of the 188 inhabitants.

Local fishermen said that the bull shark is common in west Madagascar. We examined specimens of elasmobranchs captured by trawls in shallow waters off west Madagascar, courtesy of the Overseas Fisheries Cooperative Fund. Fourteen species of elasmobranchs were reviewed but none were bull sharks or sawfish. The size of bull sharks captured was < 1.2 m TL, indicating they were young, less than age 1. Local fishermen denied the existence of large individuals in riverine areas in west Madagascar. Neither fishermen or ourselves collected specimens of the two species from the Mahajamba River. Information that local people buy shark meat at relatively high prices was provided by fishermen.

Wallace (1967) gave the description of 3 specimens of *P. microdon* and 15 of *P. pectinatus* from Durban (South Africa). However, taxonomic problems still remained as to sawfish identification, particularly of the *Pristis pristis* complex (Zorzi, 1995). We followed Compagno *et al*. (1989), Ishihara *et al*. (1991) and Compagno and Cook (1995) until a world-wide revision is made. Freshwater sawfish as far as our examination is concerned, seemed not to breed in freshwater, since specimens caught in freshwater were almost exclusively young less than one year old or immature, even if they were reported > 1.5 m (Taniuchi *et al*., 1991). A 1,450 mm male west Madagascar sawfish specimen was immature.

Urea content and osmolality of *C. leucas* specimens revealed higher values than those reported for freshwater specimens. However, the urea content was much lower than that of the marine form from the Gulf of Mexico, although osmolality was not reported in the latter case (Tab. IV). These facts suggested bull sharks might have been captured in the lower reach or the estuary of the Betsiboka River as they possessed intermediate values in urea content and osmolality. Osmolality of the sawfish suggested that they might have been captured in freshwaters rather than brackish water, but the high urea contents suggested that they were not fully adapted to freshwater like other freshwater forms of sawfishes (Tab. IV).

Sawfishes in the IUCN Red List have a global status as endangered or critically endangered species. *P. microdon* is endangered

according to the IUCN criteria A1bcde and 2bcde because all known populations have experienced serious declines resulting of fisheries and habitat loss and degradation. For instance, the small tooth sawfish, *P. pectinata*, is endangered in the Unites States (Adams and Wilson, 1995). However, our extensive field surveys suggest sawfishes may be vulnerable but not endangered in some places and their status should be regionally assessed. The bull shark is considered a species of low risk but threatened as listed in the IUCN Red List, because its occurrence in estuaries and freshwater makes it vulnerable to human impacts and habitat modifications.

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